REMARKS

Claims 1 through 67 are pending in the application. Claims 55 and 60 have been amended to replace "InGaAsSb" with "InGaAsP". Support for this amendment may be found in paragraph **[0037]** of the specification. In view of the following remarks, reconsideration and withdrawal of the rejections to the application in the Office Action is respectfully requested.

I. Double Patenting Rejection

In the Office Action, Claims 1, 2, 8, 11, 12, 15-21, 23-27, 29, 32, 34, 38, 39, 48, 49, 52, 54, 59 and 63 were rejected under the judicially created doctrine of obviousness-type double patenting as unpatentable over Claims 1-33 of U.S. Patent No. 6,791,104 (hereinafter "the '104 Patent") in view of Peter, et al., *Light –emitting diodes and laser diodes based on a* $Ga_{1-x}In_xAs/GaAs_{1-y}Sb_y$, App. Phys. Lett. 74, 1951 (1999) (hereinafter "Peter et al.").

In making this rejection, the Examiner has reiterated the rejection presented in the previous Office Action, mailed September 14, 2005, stating:

> Claims 1 - 33 do not disclose that the substrate is an InP substrate. However, Peter et al. discloses an optoelectronic device with an InP substrate. Note the first column of page 1951 of Peter et al. Peter et al. explain that the binary InP substrate is advantageous in that it is commercially used and thus technically advanced, has good thermal conductivity and low electrical resistance. Therefore, it would have been obvious to a person having skill in the art to replace the substrate of the device of claims 1 – 33 with the InP substrate such as taught by Peter, et al. in order to provide a substrate that is technically advanced, has good thermal conductivity and low electrical resistance to thus provide higher reliability.

Applicants respectfully traverse.

Unfortunately, the Examiner appears to have misinterpreted Applicants' previously filed rebuttal arguments as suggesting that one of ordinary skill in the art would not have the technical skills to make the replacement suggested by the Examiner. In response, Applicants wish to make

it clear that they have not taken the position that "one of skill in the art would lack the technical know-how to lattice match alloys of indium, gallium, arsenic and nitrogen to an InP substrate," as stated by the Examiner in paragraph 1 of the present Office Action. Instead, Applicants have argued that one of ordinary skill in the art would not expect that the simple replacement of the GaAs substrate in the device described in the '104 Patent with the InP substrate described in Peter, would successfully produce a functioning optoelectronic device. Because it appears that the Examiner misconstrued this argument as presented in Applicants' reply of December 13, 2005, the argument is presented again, in more detail, below.

In order to establish a prima facie case of obviousness, the cited prior art references must provide some motivation or suggestion to combine reference teachings and that motivation or suggestion must be based on a reasonable expectation of success, which requires at least some degree of predictability. (MPEP 2142 and 2143.02) The fact that making the claimed invention is within the capabilities of one of ordinary skill in the art is not sufficient by itself to establish prima facie obviousness. (MPEP 2143.01)

Each of the rejected claims recites an optoelectronic device that includes a hole quantum well layer containing antimony and an electron quantum well layer containing nitrogen built on an InP substrate. As noted by the Examiner, antimony-containing hole quantum well layers, nitrogen-containing electron quantum well layers and InP substrates are each individually known in the art. However, in light of the unpredictable nature of semiconductor based optoelectronic devices, the prior art does not provide motivation to select these individual components from different prior art devices and combine them into a single, functioning, optoelectronic device. As one of ordinary skill in the art would recognize, the building of a functional semiconductor-based optoelectronic device is no simple feat. Although the chemical and physical properties of each individual material in the device might be well characterized, the properties and behavior of the materials combined in a semiconductor stack is not easily predicted. Just a few of the many properties of the materials that have an effect on their ability to provide a functioning optoelectronic device (and the emission properties of any resulting device) include lattice mismatch and lattice strain, conduction band offsets, refractive index contrasts and relative

thermal and electrical conductivities. Based on the complicated interplay between these and other material properties, it would be unreasonable to assume that one could just mix and match the semiconductor layers from different devices and come up with a functioning optoelectronic device. Thus, at best, the prior art cited by the Examiner invites the reader to try each of numerous possible substrates, hole quantum well layers and electron quantum well layers until he possibly produces an operational optoelectronic device. However, any rejection of the claims based on such a general invitation would involve the application of an improper "obvious to try" rationale. (MPEP 2145)

In the present application, the inventors have done much more than simply mix and match semiconductor layers from different optoelectronic devices in the blind hope of producing a functioning optoelectronic device. As described in paragraphs 0028 and 0029 and illustrated in FIGS. 1-4 of the specification, the inventors performed the calculations necessary to simulate the claimed devices in order to determine which systems would provide an operational optoelectronic device. These calculations were needed to assess the properties of the systems based on the energy bandgap dependence on material composition, strain induced bandgap shifts, quantum confined states, carrier densities and optical response functions, among other factors. This information was used to determine what material compositions and thicknesses were needed for a given substrate. As one of ordinary skill in the art would recognize, such calculations and simulations are far from routine or trivial.

Thus, based on the complicated behavior of semiconductor materials in optoelectronic structures containing many interfacing layers of different semiconductor materials, and the art-recognized need to conduct complex calculations and simulations to understand the optical and emission properties of such structures, Applicants respectfully submit that the cited prior art is insufficient to render the rejected claims obvious. For this reason, Applicants respectfully request that this rejection be withdrawn.

Regarding claims 27, 54, 59 and 63, the Examiner further states that the optoelectronic devices described in the '104 Patent include an electron quantum well layer of InAsN. The

Examiner further asserts that "an electron quantum well layer of InAsN", as cited in the claims, must be interpreted as an electron quantum well layer *comprising* InAsN, and that such layers must actually be InGaAsN. The Examiner bases assertion on the fact that, according to Harris Jr. et al., "The band gap of gallium-free InAsN goes negative (optically inactive, metallic) at a lattice constant of 5.96 angstroms, well above the lattice constant of InP," in combination with the assertion (which is falsely attributed to the Applicants) that a non-lattice matched device cannot "reasonably" be expected to provide a functioning optoelectronic device.

Applicants respectfully note that they have never taken the position that "a non-lattice matched device cannot be expected to provide a functioning optoelectronic device." No such statement appears in Applicants' previous reply, mailed on December 13, 2005. In fact, Applicants discussion of strain in both the specification and the previous reply clearly indicates that Applicants recognize the InAsN and InP substrate do not have to be exactly lattice matched to provide a functioning optoelectronic device. Moreover, Applicants explicitly refer to InAsN and InGaAsN as alternative materials throughout the specification. In view of this, Applicants respectfully submit that claims 27, 54, 59 and 63 clearly recite an electron quantum well layer of InAsN and *not* an electron quantum well layer of InGaAsN. Therefore, because '104 Patent fails to teach or suggest an electron quantum well layer of InAsN, Applicants respectfully request that the rejection of claims 27, 54, 59 and 63 be withdrawn.

II. Rejection of Claims Under 35 U.S.C. § 103(a) Over Peter et al. in View of Major

Claims 1, 2, 5, 8, 11-16, 18, 21, 24-29, 32, 34- 41, 43-46, 48-51, 54, 59 and 63-65 were rejected under 35 U.S.C. § 103(a) as obvious over Peter, et al. in view of U.S. Patent No. 5,689,123, issued to Major et al. (hereinafter "Major"). Applicants respectfully traverse. In support of this rejection, the Examiner asserts that although Peter et al. does not disclose an electron quantum well layer containing nitrogen, it would have been obvious to a person having skill in the art that to replace the InAs of the first semiconductor layer with the InAsN layer taught by Major. Applicants respectfully traverse.

Applicants first note that Peter et al. describes a laser diode including an electron quantum well layer of GaInAs and not an electron quantum well layer of InAs. In characterizing the quantum well layer of Peter et al. as an InAs layer, the Examiner appears to be assuming that the Ga could be omitted from the GaInAs layer (i.e., that x = 1 in the formula $Ga_{1-x}In_xAs$). However, as one of ordinary skill in the art would recognize, the elimination of Ga from the GaInAs layer in the structure of Peter et al. would make the material deviate too far from the lattice matching condition (x = 0.53), causing the material to fail. In view of this, it is clear that Peter et al. is properly understood to teach a device that includes GaInAs, and not InAs. Thus, to the extent that Major is relevant it all, it is relevant only to the extent that it provides a discussion of the effect of nitrogen content on a layer of GaInAs.

The very limited discussion of the effect of nitrogen content on the properties of an InGaAs layer provided by Major is insufficient to motivate one of ordinary skill in the art to replace the GaInAs layer described by Peter et al. with the InGaAsN layer described in Major. In making this rejection, the Examiner relies on the statement, "for $In_{0.75}Ga_{0.25}As_{1-x}N_x$, the bandgap reduces from 0.62eV (corresponding to 2.0 μm emission) for x = 0 to 0.53 eV (corresponding to 2.34 μm emission) for x = 0.01." However, this single statement, which estimates the bandgap of an individual InGaAsN layer, does not address the effects on material properties that would result if the GaInAs layer was incorporated into the device structure of Peter et al. This is critical because the properties of a semiconductor layer in an optoelectronic device reflect not only the nature of the material in that individual layer, but the structure and nature of the other materials in the device, including the substrate and any neighboring hole quantum well layers. For example, strain induced bandgap shifts, carrier densities, optical matrix elements and electron and hole wavefunction overlap effect gain and emission wavelength, which determine the ability of a particular structure to perform as an optoelectronic device and the characteristics of that device. Each of these properties is a complex function of the interaction between the various layers in a device structure which cannot be predicted based on the calculated bandgap for a single layer in the device. Thus, as one of ordinary skill in the art would recognize, Major's statement that, "for $In_{0.75}Ga_{0.25}As_{1-x}N_x$, the bandgap reduces from 0.62eV (corresponding to 2.0

μm emission) for x = 0 to 0.53 eV (corresponding to 2.34 μm emission) for x = 0.01" does not provide enough information to suggest that replacing the GaInAs layer in the device described by Peter et al. with the InGaAsN layer described by Major would provide a functioning optoelectronic device. For this reason, Applicants respectfully request that this rejection be withdrawn.

III. Rejection of Claims Under 35 U.S.C. § 103(a) Based on Dapkus in View of Peter et al.

Claims 1, 3-10 and 55 and 56 were rejected under 35 U.S.C. § 103(a) as unpatentable over U.S. Patent No. 6,612,842 issued to Dapkus (hereinafter "Dapkus") in view of Peter, et al.

In making this rejection, the Examiner has reiterated the rejection presented in the previous Office Action, mailed September 14, 2005, stating:

> Dapkus does not disclose that the substrate is an InP substrate. However, Peter et al. discloses an optoelectronic device with an InP substrate. Note the first column of page 1951 of Peter et al. Peter et al. explain that the binary InP substrate is advantageous in that it is commercially used and thus technically advanced, has good thermal conductivity and low electrical resistance. Therefore, it would have been obvious to a person having skill in the art to replace the substrate of the device of Dapkus with the InP substrate such as taught by Peter, et al. in order to provide a substrate that is technically advanced, has good thermal conductivity and low electrical resistance to thus provide higher reliability.

Applicants respectfully traverse.

As discussed in Section I, above, Applicants again note that the Examiner appears to have misinterpreted Applicants' previously filed rebuttal arguments as suggesting that one of ordinary skill in the art would not have the technical skills to make the replacement suggested by the Examiner. In response, Applicants reiterate that they have not taken the position that "one of skill in the art would lack the technical know-how to lattice match alloys of indium, gallium, arsenic and nitrogen to an InP substrate," as stated by the Examiner in paragraph 1 of the present Office Action. Instead, Applicants have argued that one of ordinary skill in the art would not

expect that the simple replacement of the GaAs substrate in the device described in Dapkus with the InP substrate described in Peter et al., would successfully produce a functioning optoelectronic device. As in Section I, above, this conclusion is based on the recognition that in view of the complicated behavior of semiconductor materials in optoelectronic structures containing many interfacing layers of different semiconductor materials, and the art-recognized need to conduct complex calculations and simulations to understand the optical and emission properties of such structures, one of skill in art would not be motivated to simply mix and match various semiconductor layers from different optoelectronic devices in the blind hope of producing a functioning optoelectronic device. The Examiner is referred to Section I above for a more detailed discussion of this issue.

In view of the foregoing remarks, applicants respectfully submit that all of the claims remaining in the application are in condition for allowance and favorable action thereon is respectfully solicited.

Respectfully submitted,

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